

Appl. No. 10/758,552  
Amdt. dated March 30, 2005  
Reply to Office Action of December 30, 2004

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (original). A catalyst suitable for production of hydrogen, said catalyst consisting essentially of:

- a. a primary transition metal selected from the group consisting of a Group VIII metal, a Group IB metal, cadmium and a combination thereof, said primary transition metal being present at a predetermined concentration [Primary TM];
- b. a transition metal promoter present at a predetermined concentration [Promoter] selected such that a ratio defined by [Primary TM]:[Promoter] is greater than 1:1; and
- c. a support material comprising cerium oxide and an additive selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof,

wherein said transition metal and said promoter are combined with said support material to form said catalyst.

Claim 2 (original). The catalyst of Claim 1 wherein said primary transition metal is present at a concentration of up to about 20 wt%.

Claim 3 (original). The catalyst of Claim 2 wherein said primary transition metal is selected from the group consisting of iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, cadmium and a combination thereof.

Claim 4 (original). The catalyst of Claim 1 wherein said promoter is selected from the group consisting of lithium, potassium, rubidium, cesium, titanium, vanadium, niobium, molybdenum, tungsten, manganese, rhenium, iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, and a combination thereof.

Claim 5 (original). The catalyst of Claim 1 wherein said support material comprises cerium oxide at a concentration of greater than about 10 wt%.

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Claim 6 (original). The catalyst of Claim 1 wherein said support material has a surface area of from about 10 m<sup>2</sup>/g to about 200 m<sup>2</sup>/g.

Claim 7 (original). The catalyst of Claim 1 wherein said catalyst is combined with a substrate, wherein said substrate is a monolith, a foam, a sphere, an extrudate, a tab, a pellet, a multi-passage substrate or a combination thereof.

Claim 8 (currently amended). A catalyst suitable for conversion of hydrogen, said catalyst comprising:

- a. a primary transition metal present at a predetermined concentration [Primary TM] of up to about 20 wt% and selected from the group consisting of iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, cadmium and a combination thereof;
- b. a transition metal promoter present at a predetermined concentration [Promoter] and selected from the group consisting of lithium, potassium, rubidium, cesium, titanium, vanadium, niobium, molybdenum, tungsten, manganese, rhenium, iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, and a combination thereof; and
- c. a support material comprising cerium oxide at a concentration of greater than about 10 wt%, and an additive present at a concentration of up to about 90 wt% and selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof, and an additive present at a concentration of up to about 90 wt% and selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof,

wherein said transition metal and said promoter are combined with said support material to form said catalyst and a ratio defined by [Primary TM]:[Promoter] is greater than 1:1.

Claim 9 (cancelled). ~~The catalyst of Claim 8 wherein said support material further includes an additive selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof.~~

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Claim 10 (cancelled). ~~The catalyst of Claim 9 wherein said additive is present at a concentration of from about 0 wt% to about 90 wt%.~~

Claim 11 (original). The catalyst of Claim 8 wherein said support material is a mixed cerium zirconium oxide comprising zirconium at a higher weight percent than cerium.

Claim 12 (original). The catalyst of Claim 8 wherein said support material is a mixed cerium zirconium oxide comprising cerium at a higher weight percent than zirconium.

Claim 13 (currently amended). A catalyst suitable for conversion of hydrogen for chemical processing, said catalyst comprising:

- a. a primary transition metal present at a predetermined concentration [Primary TM] of up to about 20 wt% and selected from the group consisting of iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, cadmium and a combination thereof;
- b. a transition metal promoter present at a predetermined concentration [Promoter] and selected from the group consisting of lithium, potassium, rubidium, cesium, titanium, vanadium, niobium, molybdenum, tungsten, manganese, thenium, iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, and a combination thereof; and
- c. a support material comprising cerium oxide at a concentration of greater than about 10 wt%, and an additive present at a concentration of up to about 90 wt% and selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof.

wherein said transition metal is impregnated onto the support material to form a transition metal inclusive support and said inclusive support is then calcined; and said transition metal promoter is impregnated onto said inclusive support and calcined to form a promoter inclusive catalyst.

Claim 14 (original). The catalyst of Claim 13 wherein said primary transition metal is delivered to said support as a solvent containing a predetermined concentration of a first transition metal precursor defined as a transition metal complex having at least one ligand and wherein said ligand is absent of sulfur, chlorine, sodium, bromine, and iodine, and wherein said promoter is delivered to said transition metal inclusive support as a solvent containing a predetermined concentration of said a second transition metal precursor defined as a transition

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metal complex having at least one ligand and wherein said ligand is absent of sulfur, chlorine, sodium, bromine, and iodine.

Claim 15 (original). The catalyst of Claim 14 wherein said first transition metal precursor is a transition metal complex having ligands selected from the group consisting of ammonia, primary amines, secondary amines, tertiary amines, quaternary amines, nitrates, nitrites, hydroxyl groups, carbonyls, carbonates, aqua ions, oxides, oxylates, and combinations thereof.

Claim 16 (original). The catalyst of Claim 14 wherein said first transition metal precursor is selected from the group consisting of platinum tetra-amine hydroxide, platinum tetra-amine nitrate, platinum di-amine nitrate and a combination thereof.

Claim 17 (original). The catalyst of Claim 14 wherein said second transition metal precursor is selected from the group consisting of ammonium perhenate, a rhenium oxide complex,  $\text{ReO}_2$ ,  $\text{ReO}_3$  or  $\text{Re}_2\text{O}_7$ .

Claim 18 (cancelled). The catalyst of Claim 13 wherein said support material further includes an additive present at a concentration of up to about 90 wt% and selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof.

Claim 19 (original). The catalyst of Claim 13 wherein said [Primary TM] and [Promoter] define a ratio [Primary TM]:[Promoter] that is greater than 1:1.

Claim 20 (original). The catalyst of Claim 13 wherein said catalyst is combined with a substrate, wherein said substrate is a monolith, a foam, a sphere, an extrudate, a tab, a pellet, a multi-passage substrate or a combination thereof.

*Attachment: Clean Unmarked Version of Claims Now in Application*

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**Clean Unmarked Version of Claims Now in Application**

**Claim 1.** A catalyst suitable for production of hydrogen, said catalyst consisting essentially of:

- a. a primary transition metal selected from the group consisting of a Group VIII metal, a Group IB metal, cadmium and a combination thereof, said primary transition metal being present at a predetermined concentration [Primary TM];
- b. a transition metal promoter present at a predetermined concentration [Promoter] selected such that a ratio defined by [Primary TM]:[Promoter] is greater than 1:1; and
- c. a support material comprising cerium oxide and an additive selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof,

wherein said transition metal and said promoter are combined with said support material to form said catalyst.

**Claim 2.** The catalyst of Claim 1 wherein said primary transition metal is present at a concentration of up to about 20 wt%.

**Claim 3.** The catalyst of Claim 2 wherein said primary transition metal is selected from the group consisting of iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, cadmium and a combination thereof.

**Claim 4.** The catalyst of Claim 1 wherein said promoter is selected from the group consisting of lithium, potassium, rubidium, cesium, titanium, vanadium, niobium, molybdenum, tungsten, manganese, rhenium, iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, and a combination thereof.

**Claim 5.** The catalyst of Claim 1 wherein said support material comprises cerium oxide at a concentration of greater than about 10 wt%.

**Claim 6.** The catalyst of Claim 1 wherein said support material has a surface area of from about 10 m<sup>2</sup>/g to about 200 m<sup>2</sup>/g.

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Claim 7. The catalyst of Claim 1 wherein said catalyst is combined with a substrate, wherein said substrate is a monolith, a foam, a sphere, an extrudate, a tab, a pellet, a multi-passage substrate or a combination thereof.

Claim 8. A catalyst suitable for conversion of hydrogen, said catalyst comprising:

- a. a primary transition metal present at a predetermined concentration [Primary TM] of up to about 20 wt% and selected from the group consisting of iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, cadmium and a combination thereof;
- b. a transition metal promoter present at a predetermined concentration [Promoter] and selected from the group consisting of lithium, potassium, rubidium, cesium, titanium, vanadium, niobium, molybdenum, tungsten, manganese, thenium, iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, and a combination thereof; and
- c. a support material comprising cerium oxide at a concentration of greater than about 10 wt%, and an additive present at a concentration of up to about 90 wt% and selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof, and an additive present at a concentration of up to about 90 wt% and selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof,

wherein said transition metal and said promoter are combined with said support material to form said catalyst and a ratio defined by [Primary TM]:[Promoter] is greater than 1:1.

Claim 11. The catalyst of Claim 8 wherein said support material is a mixed cerium zirconium oxide comprising zirconium at a higher weight percent than cerium.

Claim 12. The catalyst of Claim 8 wherein said support material is a mixed cerium zirconium oxide comprising cerium at a higher weight percent than zirconium.

Claim 13. A catalyst suitable for conversion of hydrogen for chemical processing, said catalyst comprising:

- a. a primary transition metal present at a predetermined concentration [Primary TM] of up to about 20 wt% and selected from the group consisting of iron,

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cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, cadmium and a combination thereof;

- b. a transition metal promoter present at a predetermined concentration [Promoter] and selected from the group consisting of lithium, potassium, rubidium, cesium, titanium, vanadium, niobium, molybdenum, tungsten, manganese, rhenium, iron, cobalt, nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, and a combination thereof; and
- c. a support material comprising cerium oxide at a concentration of greater than about 10 wt%, and an additive present at a concentration of up to about 90 wt% and selected from the group consisting of gadolinium, samarium, zirconium, lithium, cesium, lanthanum, praseodymium, manganese, titanium, tungsten, neodymium and a combination thereof,

wherein said transition metal is impregnated onto the support material to form a transition metal inclusive support and said inclusive support is then calcined; and said transition metal promoter is impregnated onto said inclusive support and calcined to form a promoter inclusive catalyst.

**Claim 14.** The catalyst of Claim 13 wherein said primary transition metal is delivered to said support as a solvent containing a predetermined concentration of a first transition metal precursor defined as a transition metal complex having at least one ligand and wherein said ligand is absent of sulfur, chlorine, sodium, bromine, and iodine, and wherein said promoter is delivered to said transition metal inclusive support as a solvent containing a predetermined concentration of said a second transition metal precursor defined as a transition metal complex having at least one ligand and wherein said ligand is absent of sulfur, chlorine, sodium, bromine, and iodine.

**Claim 15.** The catalyst of Claim 14 wherein said first transition metal precursor is a transition metal complex having ligands selected from the group consisting of ammonia, primary amines, secondary amines, tertiary amines, quaternary amines, nitrates, nitrites, hydroxyl groups, carbonyls, carbonates, aqua ions, oxides, oxylates, and combinations thereof.

**Claim 16.** The catalyst of Claim 14 wherein said first transition metal precursor is selected from the group consisting of platinum tetra-amine hydroxide, platinum tetra-amine nitrate, platinum di-amine nitrate and a combination thereof.

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Claim 17. The catalyst of Claim 14 wherein said second transition metal precursor is selected from the group consisting of ammonium perrhenate, a rhenium oxide complex,  $\text{ReO}_2$ ,  $\text{ReO}_3$  or  $\text{Re}_2\text{O}_7$ .

Claim 19. The catalyst of Claim 13 wherein said [Primary TM] and [Promoter] define a ratio [Primary TM]:[Promoter] that is greater than 1:1.

Claim 20. The catalyst of Claim 13 wherein said catalyst is combined with a substrate, wherein said substrate is a monolith, a foam, a sphere, an extrudate, a tab, a pellet, a multi-passage substrate or a combination thereof.